HL 21: Symposium Semiconductor Nanowires

Time: Tuesday 15:15–17:45 Location: ER 270

Invited Talk HL 21.1 Tue 15:15 ER 270

Electron Transport in InAs Nanowire Quantum Dots — •Andreas Fuhrer[1,2], Carina Fasth[1], and Lars Samuelson[1] — [1]The Nanometer Structure Consortium, Lund Universtity, Box 118, S-221 00 Lund, Sweden — [2]School of Physics, University of New South Wales, Sydney, New South Wales 2052, Australia

We investigate electron transport in single [1,2] and double quantum dots [3-5] defined in catalytically grown InAs nanowires containing down to a single electron. We determine g-factor [1] and strength of the spin-orbit interaction [2] directly from excited state measurements in these few electron quantum dots. Using local gates to deplete homogeneous InAs nanowires offers a high degree of tunability for defining double quantum dots [2]. Here we show that such systems are ideally suited to manipulate single spins and charges for electron pumping [4], charge read-out [5] and spin manipulation applications.

[1] M. T. Björk, A. Fuhrer, et al. Phys. Rev. B 72, 201307 (2005)
[2] C. Fasth, A. Fuhrer, et al. Phys. Rev. Lett. 98, 266801 (2007)
[3] C. Fasth, A. Fuhrer, et al. Nano Letters 5, 1487 (2005)
[4] A. Fuhrer, C. Fasth, et al. Appl. Phys. Lett. 91, 052109 (2007)
[5] D. Wallin, A. Fuhrer, et al. Appl. Phys. Lett. 90, 172112 (2007)

Invited Talk HL 21.2 Tue 15:45 ER 270

Electronic properties of gate defined and etched quantum dots in InAs nanowires — •Ivan Shorubalko[1], Andreas Pfund[1], Simon Gustavsson[1], Renaud Leturcq[1], Silke Schön[2], and Klaus Ensslin[1] — [1]Solid State Physics Laboratory, ETH Zurich, 8093 Zurich, Switzerland — [2]FIRST lab, ETH Zurich, 8093 Zurich, Switzerland

Two different methods to fabricate few-electron quantum dots (QDs) in InAs nanowires (NWs) and a highly sensitive charge detector are demonstrated. In the first method QDs are defined electrostatically by top finger-gates. This simple technique produces high quality and fully tunable QDs containing a small number of electrons. For particular spin configurations in the double dot, we observe that the current can be suppressed due to the Pauli exclusion principle. We use this Pauli blockade spectroscopy to investigate spin relaxation mechanisms, as well as mixing of spin states. In the second method we use a single local-wet-etching step to fabricate a QD in a NW and a quantum point contact (QPC) in an underlying two-dimensional electron gas. The self-aligned QPC is used as a local gate for the QD and as a charge read-out at the same time. Charge stability diagrams measured by transport through the quantum dot and charge detection merge perfectly. Experiments on counting of single electrons tunneling through the QD showed a signal to noise ratio of more than 80 (at 20kHz bandwidth). We demonstrate a measurement of the electrical current by counting electrons passing through the QD. We also show that the device works as a single photon detector in the meV range.

Invited Talk HL 21.3 Tue 16:15 ER 270

prismatic quantum heterostructures on MBE grown GaAs nanowires — •Anna Fontcuberta i Morral — Walter Schottky Institut, TU Muenchen, Garching, Germany

Semiconductor nanowires are believed to play a decisive role in the electronic and optoelectronic devices of the XXI century. Their synthesis is a rapidly expanding field, due to the expectations that nanoscale objects and their associated phenomena have to offer to basic and applied science. Here we report on a new method for the growth of GaAs nanowires and related prismatic quantum heterostructures using Molecular Beam Epitaxy (MBE), by avoiding the use of gold as seed for the nanowires. The use of Molecular Beam Epitaxy presents an additional interest, as this technique allows us to produce ultra-pure nanowires and quantum heterostructures on the nanowire facets with very high crystalline quality and atomically sharp interfaces. This new versatility of MBE in the growth of nanostructures opens great possibilities for the generation of novel devices with additional optical and electronic functionalities, as it has been previously shown in planar structures.

Invited Talk HL 21.4 Tue 16:45 ER 270

From ordered arrays of nanowires to controlled solid state reactions — •Margit Zacharias — Faculty of Appl. Science (IMTEK), Albert Ludwigs University Freiburg, Georges-Koehler-Allee 103, 79110 Freiburg — formerly at: MPI of Microstructure Physics, Weinberg 2, 06120 Halle

There has been increasing interest in intentional synthesis of nanowires and nanotubes based on a large variety of materials. A deeper understanding and a sufficient control of growth are in the center of current research interest. Strategies for position-controlled and nanopatterned growth of nanowire arrays will be demonstrated by selected examples based on ZnO nanowires as well as discussed in terms of larger scale realization and future prospects.[1] The physical properties of single ZnO nanowires will be presented on selected examples.

Recently, we demonstrated one-dimensional free-standing spinel nanotubes which were transformed from nanowires via the Kirkendall effect in solid-state reaction.[2] We expect that the nanoscale Kirkendall effect should provide a general fabrication route to hollow nanostructures, including high aspect ratio nanotubes.[3] Such ordered arrays of spinel nanotubes may possess similar application potentials as carbon nanotubes.

[1] H.J. Fan, P. Werner, M. Zacharias, Small 2 (2006) 700.
[2] H.J. Fan, M. Knez, R. Scholz, E. Pippel, K. Nielsch, D. Hesse, M. Zacharias, U. Gösele, Nature Materials 5 (2006) 627.
[3] H.J. Fan, U. Gösele, M. Zacharias, Small 3 (2007) 1660.

Invited Talk HL 21.5 Tue 17:15 ER 270

Top-Down and Bottom-Up: Nanophotonics with ZnO and Silica Nanowires — •Tobias Voss — University of Bremen, Bremen, Germany — Harvard University, Cambridge MA, USA

We used tapered silica fibers and silica nanowires fabricated in a top-down process to inject laser light into sub-wavelength ZnO nanowires obtained in a bottom-down approach. This technique allowed us to study the waveguiding properties of individual ZnO nanowires. We found that high-order waveguide modes, which carry a significant fraction of the energy at the wire surface or even outside the wire in the form of evanescent fields, were frequently excited. Finite difference time domain numerical simulations confirmed the experimental observations and provided quantitative estimates for the coupling efficiency.

We also studied femtosecond-pulse excitation of individual ZnO nanowires with 800-nm photons from a femtosecond oscillator (60 fs; 11 MHz; 80 nJ). The large ZnO bandgap of 3.37 eV at room temperature requires multi-photon processes for the excitation of electron-hole pairs in the nanowires. We observed second-harmonic generation and the excitation of blue and green photoluminescence. Part of the light emitted from the nanowire couples into its waveguide mode and is emitted from the far end of the nanowire. By comparing the spectra at the excitation spot and at the far end of the nanowire, we were able to measure the transmission losses of the non-linearly excited ZnO nanowire. We observed a significant local heating of the nanowire at the excitation spot and analyzed the temperature distribution in the nanowire with finite-element simulations.